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Atomic absorption spectrophotometric study of lead in the muscle tissue of Indian coastal fishes

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Abstract Analysis of lead in the muscle of ten edible fin fishes were done by using an atomic absorption spectrophotometer equipped with a background corrector. The concentrations of Pb in the muscles of edible fish species were compared with the prescribed values of Pb in the seafoods of other countries and it was found that the fishes collected from the coastal region of the North Eastern Bay of Bengal accumulated considerable concentrations of Pb in the body tissues. A considerable variation of lead concentrations is observed in different fish species which is closely related to biochemical factors like membrane permeability, enzyme kinetics *etc*

Keywords Lead, muscle tissue, atomic absorption spectrophotometry

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1. Introduction

The natural sources of metals in coastal waters are mainly through river run-off. The mechanical and chemical weathering of rocks serve as important major sources. In addition, metallic components contributed by the atmospheric compartment through rainfall, windblown dust, forest fires and volcanic particles also add to this. The natural concentrations of metals in sea water are very low and therefore, the possibilities of contamination are high [1]. In fact, all industrial processes involving water are potential sources of metallic contamination in coastal waters.

Pb is a common toxic heavy metal that finds its way in coastal waters through the discharge of industrial waste waters, such as from printing, dyeing, oil refineries *etc*. Antifouling paints used to prevent the growth of marine organisms at the bottom of the boats, trawlers and ships also contain Pb which ultimately is transferred to the sediment and aquatic compartment [2]. The Pb from the ambient media may enter the human system through consumption of contaminated edible fishes. Hence, the present study was undertaken to analyse the Pb concentrations in the muscle tissue of 10 edible fishes collected from the North Eastern coast of the Bay of Bengal.

2. Materials and methods

The entire network comprised of the sampling of 10 edible fin fishes from the fish landing station of Frasergaunge during November, 1999. Five samples of each species of almost the same size were collected and muscles of all the five samples were pooled together to bring an uniformity in sample analysis. All the sample preparation in the field and the laboratory were done following the procedures of Bernhard [3]. Filleted muscle tissue was dehydrated either in an oven or by a freeze-drying technique [4]. Dried tissue samples were liquified for atomic absorption spectrophotometric analysis by nitric acid digestion in closed vessels [5]. The digested samples were aspirated in the AAS (Chemito AA201) to determine the concentrations of Pb in all the sampled fish muscles. Background correction was applied to all the analyses, and the method of standard additions was used to compensate for matrix effects. Analytical accuracy and precision were checked by analyzing dried oyster and shrimp reference materials supplied by the International Laboratory of Marine Radioactivity as part of intercalibration exercises.

3. Results and discussion

The nearshore waters along the coast of India sustain a lucrative fishery and contribute about 90% of the total annual marine fish landings of the country [6]. However due to rapid industrialization and urbanization of the adjacent cities and towns, a negative impact is often exerted on this ecosystem. Pollution of the aquatic environment and its effects on living

resources, especially the fishery resources has assumed considerable importance in recent times [6]. In many cases, bioaccumulation of heavy metals may occur, which may ultimately get transferred to human system through members of different trophic levels of the food chain. The bioaccumulation of heavy metal in living organisms is however, very species specific and depends on several factors like membrane permeability, rate of excretion, binding with active sites of enzymes *etc*. It is for this reason the accumulation is not the same in all the fish species as found in the present study (Table 1 and Figure 1).

Table 1. Concentrations of Pb in the muscle tissue of fish samples collected from Frasergaunge during November, 1999.

Fin fish species	Common/local name	Pb (in μg.gm^{-1} dry wt.)
Tenualosa ilisha	Ilish	14.84
Pampus argenteus	Pomfret	3.82
Liza parsia	Parse	10 65
Liza tade	Bhangone	19.11
Polynemus paradiseus	Tapse	7 62
Thunnus albacares	Tuna	3.38
Coilia neglecta	Ruli	2.65
Cynoglossus sp	Banspata	4.16
Scatophagus argus	Paira chanda	6 43
Ilisha elongata	Dhala	18.08

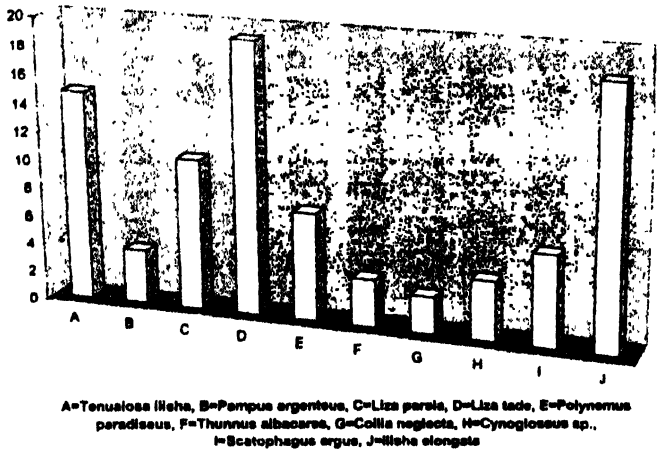

Figure 1. Concentrations of Pb (in ppm) in coastal fishes.

The difference in concentration of tissue lead in the selective fish samples was detected by AAS which works as per the Beer-Lambert law. According to this law

$$A = \varepsilon c l,$$

where A = absorbance of radiation at a particular wavelength and is expressed as the logarithmic ratio of the intensity of incident radiation (I_0) to the intensity of transmitted radiation (I),

ε = proportionality constant (molar absorptivity, mol^{-1}cm^{-1}),

C = concentration of absorbing species (mol^{-1}),

l = path length of light beam (cm).

Atomic emission spectrophotometry has long been established as a reliable analytical technique for metal analysis. Atoms absorb radiation only at discrete wavelengths characteristics of the absorbing species. Thus, radiation from the source produced from a vapour of the metal of interest, is absorbed at a discrete wavelength(s) by atoms of that element in the atomizer. As a result, the radiation beam intensity is attenuated by an amount which is proportional to the concentration of the element of interest in the atomizer. The function of atomizer (which is usually flame or furnace type electrothermal device) is to produce free atoms from the introduced sample. Radiation of a characteristics wavelength is usually produced by a hollow cathode or electrodeless discharge lamp. A monochromator placed after the atomizer (to reduce the light flux on the detector system) is used to isolate the desired wavelength from the absorbing and non-absorbing lines. The present AAS model (Chemito AAS203) is attached with a deuterium lamp for background corrections which has a high speed of operation at frequency of 1024 Hz. There is also the system of continuous adjustment of deuterium lamp current, (range 100 mA to 300 mA) with step of 1 mA for automatic balancing of light beam. The absorbances generated by the unknown samples (prepared by acid digestion of fish muscles) were finally transformed into concentrations (in ppm level) considering the absorbance values of three standards of known concentrations. Finally, the accumulated Pb in the fish muscles were expressed in μg.gm^{-1} dry weight basis.

The main source of Pb in the ambient media around the Frasergaunge station are the antifouling paints used for conditioning the fishing vessels and trawlers that are landed in large numbers in and around the fish landing stations [2]. Absorption of heavy metals from solutions by plants and animals is generally aided by passive diffusion across gradients created by adsorption at surface and by binding through constituents of the surface cells, body fluids *etc*. An alternative and important pathway for metal transference in animal species is through food particles, which has not been investigated in the present study. The regulatory mechanism of metal in the body of all animal species varies considerably and perhaps because of this variation, Pb in the fish tissues accumulated species-wise in the order *Liza tade* > *Ilisha elongata* > *Tenulosa ilisha* > *Liza parsia* > *Polynemus paradiseus* > *Scatophagus argus* > *Cynoglossus sp.* > *Pampus argenteus* > *Thunnus albacares* > *Coilia neglecta*.

The normal range of Pb in the muscles of edible fishes are very neglible and in many countries a range of Pb has been prescribed beyond which the consumption is harmful (Table 2). In India, although no specific standards have yet been stipulated with respect to Pb accumulation in the commercial marine and estuarine fishes, but the present study throws light on the fact that concentration of Pb in the studied fish species is critical for consumption if a comparison is drawn with the values of Table 2.

Table 2. Legal admissible limits of Pb in seafoods.

Country	Lead (ppm)
F R G.	0.5
U K	3 0 in canned seafoods
	10.0 in shell fish
	5.0 in dry fish
	1–2 in fin fish
Netherlands	0.05 in fish and crustaceans
	2 0 in molluscs and shell fish
Spain	2 0
Sweden	1–2
Finland	2.0
Canada	0.5
Australia	2.5

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